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(54) **Apparatus and method for making an optical fiber preform**

Vorrichtung und Verfahren zum Herstellen einer Vorform für optische Faser

Procédé et appareil pour la fabrication d'une préforme pour fibre optique

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Description

Background of the Invention

[0001] This invention relates to an apparatus for making an optical fiber preform, which can be drawn into a fiber with an improved core/clad concentricity.

[0002] In the manufacture of an optical fiber, a preform is typically made using either outside vapor deposition (OVD), vapor axial deposition (VAD) or modified chemical vapor deposition (MCVD) techniques. OVD and VAD preforms are then dehydrated and consolidated to form a solid glass blank while MCVD preforms are collapsed to form a solid glass blank. The glass blanks are then drawn into fiber. Alternatively, the glass blanks can be drawn into core cane which is then overclad using OVD or rod-in-tube techniques to form an overclad preform. The overclad preform is subsequently dehydrated and consolidated to form an overclad glass blank which is then drawn into fiber.

[0003] One parameter of interest in the drawn fiber is the core/clad concentricity (hereinafter referred to as concentricity). Concentricity is a measure of how well the core of a fiber is centered with respect to the overall center of the fiber. FIG. 7 shows a cross-section of an optical fiber 70 with core region 71 having center A and clad region 72 having center B. The concentricity can then be characterized by the distance X between core center A and clad center B.

[0004] It is believed that for an overclad preform, the concentricity is determined during the overclad deposition step. For instance, in a cane assembly a rod may be attached to an upper cane handle and a lower cane handle, and FIG. 1 of the accompanying drawings shows a cane assembly 1 with a rod 2 attached to upper and lower cane handles 3 and 4. If the cane assembly is not made perfectly straight, it will wobble when rotated during the soot deposition process, resulting in uneven deposition of soot around the cane due to the relative movement of the cane assembly with respect to the soot stream. Even if a cane assembly could be made perfectly straight, wobble is likely to develop because of changes in stresses in the cane assembly which result from heating the cane assembly during the soot deposition process, particularly as both length and diameter of an optical fiber preform have been increased in recent years. It becomes necessary to adjust the chucks holding the cane assembly, which is tedious and time consuming, and has to be done repeatedly, as heating of the cane assembly during the soot deposition process will change the stress pattern within the case and will again produce a wobble. U.S. Patents 4,126,436 and 5,067,975 mention diameter upsets from thermal changes in the blank.

[0005] It is an object of the present invention to improve the core/clad concentricity of an optical fiber by reducing the wobble during overclad soot deposition.

Summary of the Invention

[0006] According to the present invention there is provided an apparatus for holding a cane assembly, said cane assembly having a longitudinal axis, during soot deposition to form an optical waveguide preform, comprising:

(a) first holding means holding a first end of said cane assembly, said first holding means being rotatable about the longitudinal axis of said cane assembly,
(b) second holding means for holding a second end of said cane assembly, said second holding means being rotatable about the longitudinal axis of said cane assembly and fixed in the direction of said longitudinal axis, and
(c) first means associated with said first holding means for generating a first tensile force along the longitudinal axis of said cane assembly. The tensile force serves to reduce wobble induced by changes in stress resulting from heating which occurs during the soot deposition process. The apparatus preferably comprises a chucking device which substantially reduces the time required to load a cane assembly into an apparatus for depositing soot thereon and which provides precise and rigid chucking of the ends of a cane assembly.

[0007] The invention also provides a method for depositing soot on a rotating cane assembly (10, 100, 80), said rotating cane assembly having a longitudinal axis, comprising

(a) applying a tensile force along the longitudinal axis of said rotating cane assembly while soot is being deposited on said rotating cane assembly, and

(b) controlling the radial uniformity of the soot deposited on said cane assembly by controlling said tensile force applied to said rotating cane assembly.

Brief Description of the Drawings

[0008]

FIG. 1 as mentioned above, shows a cane assembly with a rod attached to upper and lower cane handles and typically used in a soot deposition process to form an optical waveguide soot preform.
FIG. 2 is a schematic of a typical apparatus used in a soot deposition process.
FIG. 3 is an upper cane chucking assembly according to one aspect of the present invention.
FIG. 4 is a lower cane chucking assembly according to one aspect of the present invention.

FIG. 5 is a bearing assembly according to one aspect of the present invention.

FIG. 6 is a bearing system according to another aspect of the present invention.

FIG. 7 is a representation of core/clad concentricity.

FIG. 8 is a cane assembly tensioning system according to another aspect of the present invention which uses a weight to apply a tensile force.

Detailed Description

[0009] FIG. 2 depicts a typical known apparatus used in a soot deposition process. Cane assembly 10 is placed in upper chuck 11. Lower chuck 12 is attached to the lower end of cane assembly 10. Upper chuck 11 is attached to upper spindle 13. Upper spindle 13 is also attached to spindle motor 14 which is in turn attached to weighing device 15. Lower chuck 12 is attached to lower spindle 16. Burner 21 is provided to deposit soot on the cane assembly 10. Air bearings 17, 18, 19, 20 are provided which are essentially frictionless in the direction of the axis of cane assembly 10.

[0010] FIG. 3 depicts an upper cane chucking assembly 30 according to one aspect of the present invention. Upper cane chucking assembly 30 of FIG. 3 is positioned similarly to upper chuck 11 of FIG. 2. Upper cane handle 31 (similar to upper cane handle 3 of FIG. 1) is supported vertically by cup 32. Cup 32 is allowed to move in a plane which is perpendicular to the axis of upper cane 31. Shell clamp 33 rigidly positions upper cane handle 31 in a plane which is perpendicular to the axis of the upper cane handle. Knob 34 is used to open and close shell clamp 33. The diameter of upper cane handle 31 matches the inner diameter of shell clamp 33 so that upper cane handle 31 is precisely and rigidly held. Upper spindle 35 of FIG. 3 is positioned similarly to upper spindle 13 of FIG. 2.

[0011] A lower cane chucking assembly 40 is shown in FIG. 4 and would be similarly positioned on the soot deposition apparatus as lower chuck 12 in FIG. 1. Lower cane handle 41 is inserted into lower cane chucking assembly 40. Shell clamp 42 rigidly positions lower cane handle 41 in a plane which is perpendicular to the axis of lower cane handle 41. Knob 43 is used to open and close shell clamp 42. The diameter of lower cane handle 31 matches the inner diameter of shell clamp 42 so that lower cane handle 31 is precisely and rigidly held. Lower spindle 44 is positioned similarly to lower spindle 16 of FIG. 2. By using a centerless grinding process to form the upper and lower cane handles, handles are provided which have precise diameters and which are very round in cross-section, i.e., exhibit very little or no eccentricity about the longitudinal axis. This allows for very tight clearances between the cane handles and the inner diameters of the chucking assemblies such that the handles are precisely and rigidly held by the chucking assemblies.

[0012] By holding a cane assembly with upper and lower cane chucking assemblies as shown in FIGS. 3 and 4, the cane assembly is substantially vertical at both ends. When the upper and lower cane chucking assemblies are properly aligned relative to each other, the wobble of a cane assembly held therein is substantially reduced, by up to a factor of four.

[0013] As air bearings 17, 18, 19 and 20, as shown in FIG. 2, are essentially frictionless in the direction of the axis of the cane assembly, the cane assembly is placed in tension by the weight of the lower cane chucking assembly. It has been determined that additional tensile force on the cane assembly is preferable to reduce wobble resulting from stresses which occur in the cane assembly during soot deposition. However, for equipment reliability, it is preferable to increase the tensile force on the cane assembly without adding weight to the lower chuck. Such added weight would increase the stresses on the drive components above upper spindle 13, thereby increasing the potential for failure of those components. Also, the added weight could result in the total weight of the drive components, chucking assemblies, cane assembly and overclad soot deposited thereon exceeding the capacity of weighing device 15. Of course, it is possible to overcome this last limitation by replacing weighing device 15 with a higher capacity device, but doing so would not be preferable because a higher capacity weighing device would also reduce the precision of the weight measurements.

[0014] In order to provide additional tensile force on a cane assembly without increasing the stresses on the drive components, the air bearing assembly shown in FIG. 5 is provided. As shown in FIG. 5, air bearing assembly 50 is for use at the lower end of a cane assembly. Lower spindle 51, which is positioned similarly to lower spindle 16 of FIG. 2, is a stepped diameter shaft. The upper portion 52 of spindle 51 has a smaller diameter than the lower portion 53. Upper air bearing 54 is sized for upper portion 52 and lower air bearing 55 is sized for lower portion 53. Bearing block 56 includes air supply ports 57a and 57b, which are connected to an air supply (not shown) at sufficient pressure for operation of the air bearings. A cavity 58 is positioned in bearing block 56 between upper air hearing 54 and lower air bearing 55. Pressure regulator 59 is connected to cavity 58.

[0015] The operation of air bearing assembly 50 is as follows. Air that flows through an air bearing is forced axially along the spindle. A portion of the air is directed upwardly along the spindle and the rest of the air is directed downwardly along the shaft. As shown in FIG. 5, the air directed downwardly through upper air bearing 54 and the air directed upwardly through lower air bearing 55 flows into cavity 58. Cavity 58 is connected to the exit side of pressure regulator 59. The inlet 60 of pressure regulator 59 is connected to the same air supply as that which enters the bearing block 56 through ports 57a and 57b.

[0016] The pressure in cavity 58 can be controlled by

adjusting pressure regulator 59. Preferably, no air enters cavity 58 through regulator 59. Instead, pressure regulator 59 controls the pressure in cavity 58 by bleeding off air which enters the cavity through the air bearings.

[0017] By pressurizing cavity 58, an air piston is established with the air bearings functioning essentially as frictionless seals. The difference in the cross-sectional areas of the upper and lower portions of the spindle result in a downward force being applied to the lower portion. This downward force will be applied to a cane assembly attached to the lower spindle. The magnitude of the downward force can be adjusted by changing the difference in the cross-sectional area or by changing the pressure in cavity 58.

[0018] By turning air bearing assembly 50 upside down, the air bearing assembly can be used at the upper end of the soot deposition apparatus. By placing air bearing assemblies at both the top and bottom of the cane assembly, the tension can be increased on the cane assembly without increasing the stress on the drive components at the top of the soot deposition apparatus.

[0019] FIG. 6 shows a soot deposition apparatus with upper and lower bearing assemblies similar to that shown in FIG. 5 and described above. Cane assembly 100 is held by upper chuck 101 and lower chuck 102. Upper chuck 101 is attached to upper spindle 103, which is a stepped diameter shaft. Upper spindle 103 is constrained from moving perpendicular to its axis by upper bearing assembly 104. Upper bearing assembly 104 includes air bearings 105 and 106, air supply ports 107a and 107b, cavity 108 and pressure regulator port 109. Upper spindle 103 is attached to rotational and weighing equipment not shown but similar to that shown in FIG. 2. An upward force is generated on cane assembly 100 by the design of upper spindle 103 and upper bearing assembly 104.

[0020] Lower chuck 102 is attached to lower spindle 110. Lower spindle 110 is constrained from moving perpendicular to its axis by lower bearing assembly 111. Lower bearing assembly 111 includes air bearings 112 and 113, air supply ports 114a and 114b, cavity 115 and pressure regulator port 116. A downward force is generated on cane assembly 100 by the design of lower spindle 110 and lower bearing assembly 111.

[0021] Pressure regulator ports 109 and 116 are shown in FIG. 6 connected to one pressure regulator 117 by tension control pressure line 118. This provides for the same pressure to be present in cavities 108 and 115. If the pressures are equal in cavities 108 and 155 and the difference in cross-sectional area of the upper and lower portions of the spindles 103 and 110 are equal, the upward and downward forces, resulting from the present invention, on cane assembly 100 will be equal. Therefore, the cane assembly will be placed in tension without putting additional stress on the drive components above the upper spindle. It is possible to have separate pressure regulators for each of the cavities such that different pressures could be provided in the cavities, however, this may induce additional stress on the drive components above the upper spindle. Also, the use of a single pressure regulator, as shown in FIG. 6, avoids erroneous weight readings during the soot deposition process which can result from pressure changes caused by the heating of equipment.

[0022] The tension under which the cane assembly is held will act to move the cane assembly toward the centerline established by the upper and lower chucking assemblies. This action occurs even if the stresses in the cane assembly change as a result of heating during the soot deposition process. Therefore, wobble resulting from changes in stress in the cane assembly will be substantially reduced. The design allows for easy loading of a cane assembly and unloading of a soot preform by setting the pressure regulator such that there is no pressure in the cavities during loading and unloading operations.

[0023] The tension applied to the cane assembly may be varied during the soot deposition process. This variation may be done by manual adjustment of the pressure regulator or by providing components for the automatic measurement, adjustment and control of the pressure in the cavities. It may be desirable to adjust the tension applied to the cane assembly to reduce the potential for destruction of a preform caused by failure of the cane assembly chucking mechanisms. One example of such a failure is slippage of the lower chuck on the cane assembly which results in loss of the entire preform due to physical damage to the preform when the lower end is free of the lower chuck.

[0024] One example of the method of the present invention will be described, with reference numerals referring to those shown in FIG. 6. This example applies a tensile force to cane assembly 100, using a pneumatic system. Regulator 117 is adjusted so that normal atmospheric pressure is present in cavities 108 and 115. This results in no forces generated on upper chuck 101 or lower chuck 102 and facilitates loading of cane assembly 100 into the apparatus. Cane assembly 100 is placed into upper chuck 101 and held therein. Cane assembly 100 is then placed into lower chuck 102 and held therein. In a preferred embodiment, upper chuck 101 and lower chuck 102 are shell clamp chucks as disclosed and shown in FIGS. 3 and 4.

[0025] After placing cane assembly 100 in the chucks, regulator 117 is adjusted to provide a pressure of about 40 psi (about 2.76×10^5 Pa) in cavities 108 and 115. The cane assembly is then rotated at about 100 rpm. An OVD overclad soot deposition process, similar to that disclosed in Backer et al. U.S. Patent No. 5,067,975, is then used to produce a preform from which an optical fiber is drawn.

[0026] An optional annealing step can be used prior to the deposition of soot on the cane assembly. At least one soot deposition burner, such as that disclosed in

Backer et al., is ignited with only gas and oxygen flowing through it and no soot precursor vapors such as $SiCl_4$. The burner is then oscillated along at least a portion of the length of cane assembly 100 to anneal the cane assembly. This annealing step allows any stresses in the cane assembly to be relieved prior to the deposition of any soot thereon and improves the core/clad concentricity in fiber drawn from the blank produced using this method.

[0027] In one example of the present invention, a soot deposition apparatus similar to that shown in FIG. 6 was used. The smaller diameter of the spindle shafts was 1 in. (2.54 cm) and the larger diameter was 1.5 in. (3.81 cm). This resulted in a difference in cross-sectional area of 0.982 in^2 (6.33 cm^2). The pressure regulator was set to provide a pressure of about 40 psi (2.76 x 10^5 Pa) in the cavities. The combination of the cross-sectional area difference and the pressure in the cavities resulted in about 40 pounds (about 178 N) of force on each end of the cane assembly. In this example, an annealing process was used with six deposition burners, with total flows for all six burners of 120 slpm CH_4 and 100 slpm O_2, oscillating along about the middle 60% of the length of a cane assembly. The burners were oscillated along that portion of the cane assembly for about twelve minutes.

[0028] The core/clad concentricity of fiber drawn from preforms produced in the example described above was measured using standard test equipment. Approximately 4000 km of fiber were produced with an average core/clad concentricity of 0.228 μm and a sigma of 0.112 μm. For the approximately 15,000 km of fiber made by the same soot deposition apparatus prior to the above example, the average core/clad concentricity was 0.255 μm with a sigma of 0.13 μm. In this example, therefore, the present invention resulted in an improvement of about 10.5% in the average core/clad concentricity. Using known statistical analysis based on a skewed normal distribution, it is predicted that the present invention will result in a loss rate for concentricity of about 90 parts per million (ppm) as compared to about 480 ppm without the benefits of the present invention.

[0029] Another example of the apparatus and method of the present invention is described with reference to FIG. 8. In this example, a tensile force is applied to cane assembly 80 through the use of weight 81. Cane assembly 80 is placed in upper chuck assembly 82 and held therein, preferably by clamping means previously described with reference to FIG. 3. Weight 81 and lower chuck assembly 83 are lifted off pedestal 84 by a force generated by fluid, for example air, provided through inlet 88 under piston 87. Cane assembly 80 is placed in lower chuck assembly 83 and held therein, preferably by clamping means described with reference to FIG. 4.

[0030] After securing cane assembly 80 in upper chuck assembly 82 and lower chuck assembly 83, pressure beneath piston 87 is released. This pressure release results in a tensile force applied to cane assembly 80 due to the gravitational force of weight 81. During soot deposition, cane assembly 80 is rotated by drive means (not shown) attached to upper chuck assembly 82. Lower chuck assembly 83 rotates along with cane assembly 80. The lower end of lower chuck assembly 83 is attached to bearing 85 which is also attached to weight 81 such that lower chuck assembly 83 rotates independently of weight 81. Weight 81 is constrained from rotating by pin 86 which is inserted into both weight 81 and pedestal 84. The combination of bearing 85 and pin 86 minimizes the torsional stresses applied to cane assembly 80 during soot deposition.

[0031] Although the present invention has been described with respect to a cane assembly held in a vertical orientation during soot deposition, it is also applicable to a cane assembly held in a horizontal orientation during soot deposition. The present invention provides for the application of a tensile force along the axis of a horizontal cane assembly by using at least one air bearing assembly as described herein. Also, although the present invention has been described with respect to producing an overclad preform, it is equally applicable to the manufacture of a core preform from which core cane may be drawn. In the case of the manufacture of a core preform, a bait rod, which is preferably removed after the core soot deposition process, is used instead of a cane assembly.

Claims

1. An apparatus for holding a cane assembly (10, 100, 80), said cane assembly having a longitudinal axis, during soot deposition to form an optical waveguide preform, comprising:

   (a) first holding means (40, 102, 83) for holding a first end of said cane assembly, said first holding means being rotatable about the longitudinal axis of said cane assembly,

   (b) second holding means (30, 101, 82) for holding a second end of said cane assembly, said second holding means being rotatable about the longitudinal axis of said cane assembly and fixed in the direction of said longitudinal axis, and

   (c) first means (50; 111; 81, 84-88) associated with said first holding means for generating a first tensile force along the longitudinal axis of said cane assembly.

2. The apparatus of claim 1, further comprising second means associated with said second holding means for generating a second tensile force along the longitudinal axis of said cane assembly.

3. The apparatus of claim 1 or 2, wherein said first means (c) comprises

(i) a weight (81) attached to said first holding means (83),

(ii) a bearing (85) attached to said cane assembly (80) and to said weight (81) such that said cane assembly rotates about the longitudinal axis of said cane assembly substantially independently of said weight, and

(iii) means (86) for preventing said weight from rotating such that said weight does not substantially impart a torsional stress on said cane assembly.

4. An apparatus according to claim 1 or 2, wherein the first means for generating a first tensile force comprises first bearing means connected to said first holding means by a first spindle (51, 110), said first bearing means comprising first and second air bearings (54, 55; 112, 113) through which said first spindle is inserted, said first and second air bearings being separated by a first cavity (58; 115) which can be pressurized to a first pressure above ambient pressure,
wherein said first spindle (51, 110) has a first section (52) with a first diameter and a second section (53) with a second diameter different from said first section, the transition from said first diameter to said second diameter being located in said first cavity, and
wherein said first spindle (51, 110) and said first pressure in said first cavity generate a first force which is applied to said cane assembly along the longitudinal axis of said cane assembly, said first force being directed away from said second holding means.

5. The apparatus of claim 4 as dependent on claim 2, wherein said second means for generating a second tensile force, that is associated with said second holding means (101) comprises

second bearing means (104) connected to said second holding means (101) by a second spindle (103), said second bearing means comprising third and fourth air bearings (105, 106) through which said second spindle is inserted, said third and fourth air bearings being separated by a second cavity (108) which can be pressurized to a second pressure above ambient pressure,
wherein said second spindle (103) has a first section with a first diameter and a second section with a second diameter different from said first section, the transition from said first diameter to said second diameter being located in said second cavity (108), and
wherein said second spindle (103) and said second pressure in said second cavity (108) generate a second force which is applied to said cane assembly along the longitudinal axis of said cane assembly, said second force being directed away from said first spindle (110).

6. The apparatus of claim 4 or 5, wherein said cane assembly (10, 100, 80) is held in a vertical orientation or in a horizontal orientation.

7. The apparatus of claim 4, 5 or 6, wherein said first and second holding means (40, 102, 83; 30, 101, 82) rigidly hold said cane assembly (10, 100, 80) such that movement of said cane assembly perpendicular to the longitudinal axis of said cane assembly is constrained, and wherein said first and second holding means are aligned such that the longitudinal axes of said first and second ends of said cane assembly are substantially aligned with each other.

8. A method for depositing soot on a rotating cane assembly (10, 100, 80), said rotating cane assembly having a longitudinal axis, comprising

(a) applying a tensile force along the longitudinal axis of said rotating cane assembly while soot is being deposited on said rotating cane assembly, and

(b) controlling the radial uniformity of the soot deposited on said cane assembly by controlling said tensile force applied to said rotating cane assembly.

9. The method of claim 8, wherein said step of applying a tensile force further comprises the step of varying said tensile force while the soot is being deposited on said rotating cane assembly.

10. The method of claim 8 or 9, further comprising the step of annealing said rotating cane assembly prior to depositing soot on said rotating cane assembly.

Patentansprüche

1. Vorrichtung zum Halten einer Stabglasanordnung (10, 100, 80), wobei die Stabglasanordnung eine Längsachse aufweist, während einer Rußabscheidung zum Bilden einer Vorform für einen optischen Wellenleiter, mit:

(a) einer ersten Halteeinrichtung (40, 10, 83) zum Halten eines ersten Endes der Stabglasanordnung, wobei die erste Halteeinrichtung

um die Längsachse der Stabglasanordnung drehbar ist,

(b) einer zweiten Halteeinrichtung (30, 101, 82) zum Halten eines zweiten Endes der Stabglasanordnung, wobei die zweite Halteeinrichtung um die Längsachse der Stabglasanordnung drehbar ist und in der Richtung der Längsachse fixiert ist, und

(c) einer ersten Einrichtung (50; 111, 81, 84-88), die der ersten Halteeinrichtung zugeordnet ist, zum Erzeugen einer ersten Zugkraft entlang der Längsachse der Stabglasanordnung.

2. Vorrichtung nach Anspruch 1, gekennzeichnet durch eine zweite Einrichtung, welche der zweiten Halteeinrichtung zugeordnet ist, zum Erzeugen einer zweiten Zugkraft entlang der Längsachse der Stabglasanordnung.

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die erste Einrichtung (c) aufweist:

(i) ein an der ersten Halteeinrichtung (83) angebrachtes Gewicht (81);

(ii) ein Lager (85), das an der Stabglasanordnung (80) und an dem Gewicht (81) derart angebracht ist, daß die Stabglasanordnung um die Längsachse der Stabglasanordnung im wesentlichen unabhängig von dem Gewicht drehbar ist, und

(iii) eine Einrichtung (86) zum Verhindern, daß das Gewicht drehbar ist, so daß das Gewicht im wesentlichen keine Torsionsspannung an die Stabglasanordnung anlegt.

4. Vorrichtung nach Anspruch 1 oder 2,
dadurch gekennzeichnet, daß die erste Einrichtung zum Erzeugen einer ersten Zugkraft eine erste Lagereinrichtung aufweist, die mit der ersten Halteeinrichtung durch eine erste Spindel (51, 110) verbunden ist, wobei die erste Lagereinrichtung ein erstes und zweites Luftlager (54, 55; 112, 113) aufweist, durch das die erste Spindel einsetzbar ist, wobei das erste und zweite Luftlager durch einen ersten Hohlraum (58; 115) getrennt sind, welcher auf einen ersten Druck oberhalb des Umgebungsdrucks unter Druck gesetzt werden kann,
wobei die erste Spindel (51, 110) einen ersten -schnitt (52) mit einem ersten Durchmesser und einem zweiten Abschnitt (53) mit einem zweiten Durchmesser, der von demjenigen des ersten Abschnitts verschieden ist, aufweist, wobei der Übergang von dem ersten Durchmesser zum zweiten Durchmesser in dem ersten Hohlraum angeordnet ist, und
wobei die erste Spindel (51, 110) und der erste Druck in den ersten Hohlraum eine erste Kraft erzeugen kann, welche an die Stabglasanordnung entlang der Längsachse der Stabglasanordnung anlegbar ist, wobei die erste Kraft weg von der zweiten Halteeinrichtung gerichtet ist.

5. Vorrichtung nach Anspruch 4 in Abhängigkeit von Anspruch 2,
dadurch gekennzeichnet, daß die zweite Einrichtung zum Erzeugen einer zweiten Zugkraft, welche der zweiten Halteeinrichtung (101) zugeordnet ist, aufweist:

eine zweite Lagereinrichtung (104), welche mit der zweiten Halteeinrichtung (101) durch eine zweite Spindel (103) verbunden ist, wobei die zweite Lagereinrichtung ein drittes und viertes Luftlager (105, 106) aufweist, durch das die zweite Spindel einsetzbar ist, wobei das dritte und vierte Luftlager durch einen zweiten Hohlraum (108) getrennt sind, welcher auf einen zweiten Druck oberhalb des Umgebungsdrucks unter Druck gesetzt werden kann,
wobei die zweite Spindel (103) einen ersten Abschnitt mit einem ersten Durchmesser mit einem zweiten Abschnitt mit einem zweiten Durchmesser, der von demjenigen des ersten Abschnittes verschieden ist, aufweist, wobei der Übergang von dem ersten Durchmesser zum zweiten Durchmesser in der im zweiten Hohlraum (108) gelegen ist, und
wobei die zweite Spindel (103) und der zweite Druck in dem zweiten Hohlraum (108) eine zweite Kraft erzeugen, welche an die Stabglasanordnung entlang der Längsachse der Stabglasanordnung anlegbar ist, wobei die zweite Kraft weg von der ersten Spindel (110) gerichtet ist.

6. Vorrichtung nach Anspruch 4 oder 5,
dadurch gekennzeichnet, daß die Stabglasanordnung (10, 100, 80) in einer vertikalen Orientierung oder in einer horizontalen Orientierung gehaltert ist.

7. Vorrichtung nach Anspruch 4, 5 oder 6,
dadurch gekennzeichnet, daß die erste und zweite Halteeinrichtung (40, 102, 83; 30, 101, 82) die Stabglasanordnung (10, 100, 80) derart festhaltern, daß die Bewegung der Stabglasanordnung senkrecht zur Längsachse der Stabglasanordnung beschränkt ist, und daß die erste und zweite Halteeinrichtung derart ausgerichtet sind, daß die Längsachsen des ersten und zweiten Endes der

Stabglasanordnung im wesentlichen zueinander ausgerichtet sind.

8. Verfahren zum Abscheiden von Ruß auf einer rotierenden Stabglasanordnung (10, 100, 80), wobei die rotierende Stabglasanordnung eine Längsachse aufweist, mit den Schritten:

   (a) Anlegen einer Zugkraft entlang der Längsachse der rotierenden Stabglasanordnung, während Ruß auf die rotierende Stabglasanordnung abgeschieden wird, und

   (b) Steuern der radialen Gleichförmigkeit des auf der Stabglasanordnung abgeschiedenen Rußes durch Steuern der Zugkraft, welche an die rotierende Stabglasanordnung angelegt wird.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß der Schritt des Anlegens einer Zugkraft weiterhin den Schritt des Variierens der Zugkraft aufweist, während der Ruß auf die rotierende Stabglasanordnung abgeschieden wird.

10. Verfahren nach Anspruch 8 oder 9, gekennzeichnet durch den Schritt des Temperns der rotierenden Stabglasanordnung vor dem Abscheiden des Rußes auf der rotierenden Stabglasanordnung.

Revendications

1. Un appareil pour maintenir un ensemble de canne en verre (10, 100, 80), ledit ensemble de canne présentant un axe longitudinal, lors d'un dépôt de suie visant à former une préforme de guide d'ondes optique, comprenant :

   (a) un premier moyen de maintien (40, 102, 83) pour maintenir une première extrémité dudit ensemble de canne, ledit premier moyen de maintien pouvant tourner autour de l'axe longitudinal dudit ensemble de canne,
   (b) un deuxième moyen de maintien (30, 101, 82) pour maintenir une deuxième extrémité dudit ensemble de canne, ledit deuxième moyen de maintien pouvant tourner autour de l'axe longitudinal dudit ensemble de canne et étant fixe dans la direction dudit axe longitudinal ; et
   (c) un premier moyen (50; 111; 81, 84-88) associé audit premier moyen de maintien pour engendrer une première force de traction le long de l'axe longitudinal dudit ensemble de canne.

2. L'appareil de la revendication 1, comprenant en outre un deuxième moyen associé audit deuxième moyen de maintien pour engendrer une deuxième force de traction le long de l'axe longitudinal dudit ensemble de canne.

3. L'appareil de la revendication 1 ou 2, dans lequel ledit premier moyen (c) comprend

   (i) un poids (81) assujetti audit premier moyen de maintien (83),
   (ii) un palier (85) assujetti audit ensemble de canne (80) et audit poids (81) de sorte que ledit ensemble de canne tourne autour de l'axe longitudinal dudit ensemble de bâton de manière sensiblement indépendante dudit poids, et
   (iii) un moyen (86) pour empêcher ledit poids de tourner de sorte que ledit poids n'applique pratiquement pas d'effort de torsion audit ensemble de canne.

4. Un appareil selon la revendication 1 ou 2, dans lequel le premier moyen pour engendrer une première force de traction comprend un premier moyen d'appui relié audit premier moyen de maintien par une première broche (51, 110), ledit premier moyen d'appui comprenant un premier et un deuxième paliers à air (54, 55; 112, 113) à travers lesquels est insérée ladite première broche, lesdits premier et deuxième paliers à air étant séparés par une première cavité (58; 115) pouvant être placée à une première pression supérieure à la pression atmosphérique,
ladite première broche (51, 110) présentant une première section (52) ayant un premier diamètre et une deuxième section (53) ayant un deuxième diamètre différent de celui de ladite première section, la transition dudit premier diamètre audit deuxième diamètre étant située dans ladite première cavité, et
ladite première broche (51, 110) et ladite première pression régnant dans ladite première cavité donnant naissance à une première force qui est appliquée audit ensemble de canne le long de l'axe longitudinal dudit ensemble de canne, ladite première force étant orientée dans une direction écartée de celle dudit deuxième moyen de maintien.

5. L'appareil de la revendication 4 prise en combinaison avec la revendication 2, dans lequel ledit deuxième moyen pour engendrer une deuxième force de traction, qui est associé audit deuxième moyen de maintien (101) comprend :

   un deuxième moyen d'appui (104) relié audit deuxième moyen de maintien (101) par une deuxième broche (103), ledit deuxième moyen d'appui comprenant un troisième et un qua-

trième paliers à air (105, 106) à travers lesquels est insérée ladite deuxième broche, lesdits troisième et quatrième paliers à air étant séparés par une deuxième cavité (108) pouvant être placée à une deuxième pression supérieure à la pression atmosphérique,
ladite deuxième broche (103) présentant une première section ayant un premier diamètre et une deuxième section ayant un deuxième diamètre différent de celui de ladite première section, la transition dudit premier diamètre audit deuxième diamètre étant située dans ladite deuxième cavité, et
ladite deuxième broche (103) et ladite deuxième pression régnant dans ladite deuxième cavité (108) donnant naissance à une deuxième force qui est appliquée audit ensemble de canne le long de l'axe longitudinal dudit ensemble de canne, ladite deuxième force étant orientée dans une direction écartée de celle de ladite première broche (110).

6. L'appareil de la revendication 4 ou 5, dans lequel ledit ensemble de canne (10, 100, 80) est maintenu dans une orientation verticale ou dans une orientation horizontale.

7. L'appareil de la revendication 4, 5 ou 6, dans lequel lesdits premier et deuxième moyens de maintien (40, 102, 83; 30, 101, 82) maintiennent rigidement ledit ensemble de canne (10, 100, 80) de manière à contraindre les déplacements dudit ensemble de canne perpendiculairement à l'axe longitudinal dudit ensemble de canne, et dans lequel lesdits premier et deuxième moyens de maintien sont alignés de manière que les axes longitudinaux desdites première et deuxième extrémités dudit ensemble de canne soient sensiblement alignés entre eux.

8. Un procédé pour déposer de la suie sur un ensemble de canne (10, 100, 80) enrotation, ledit ensemble de canne en rotation présentant un axe longitudinal, comprenant les opérations consistant :

(a) à appliquer une force de traction le long de l'axe longitudinal dudit ensemble de canne en rotation pendant que de la suie est déposée sur ledit ensemble de bâton en rotation, et
(b) à agir sur l'uniformité radiale de la suie déposée sur ledit ensemble de bâton en jouant sur ladite force de traction appliquée audit ensemble de bâton en rotation.

9. Le procédé de la revendication 8, dans lequel ladite opération d'application d'une force de traction comprend en outre l'opération de variation de ladite force de traction pendant le dépôt de la suie sur ledit ensemble de canne en rotation.

10. Le procédé de la revendication 8 ou 9, comprenant en outre l'opération de recuisson dudit ensemble de canne en rotation avant le dépôt de suie sur ledit ensemble de canne en rotation.

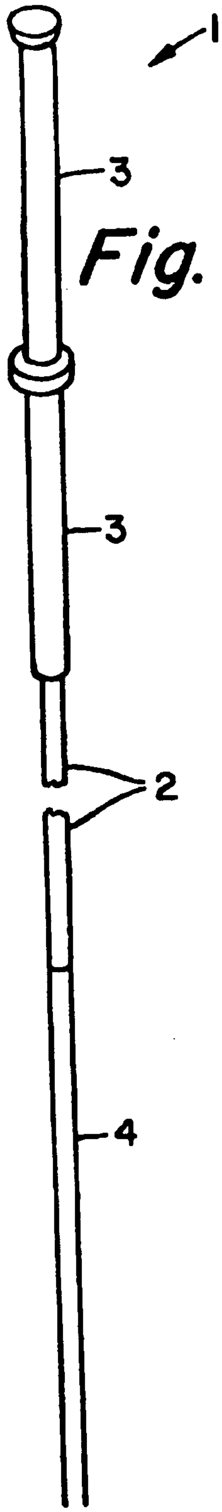

Fig. 1

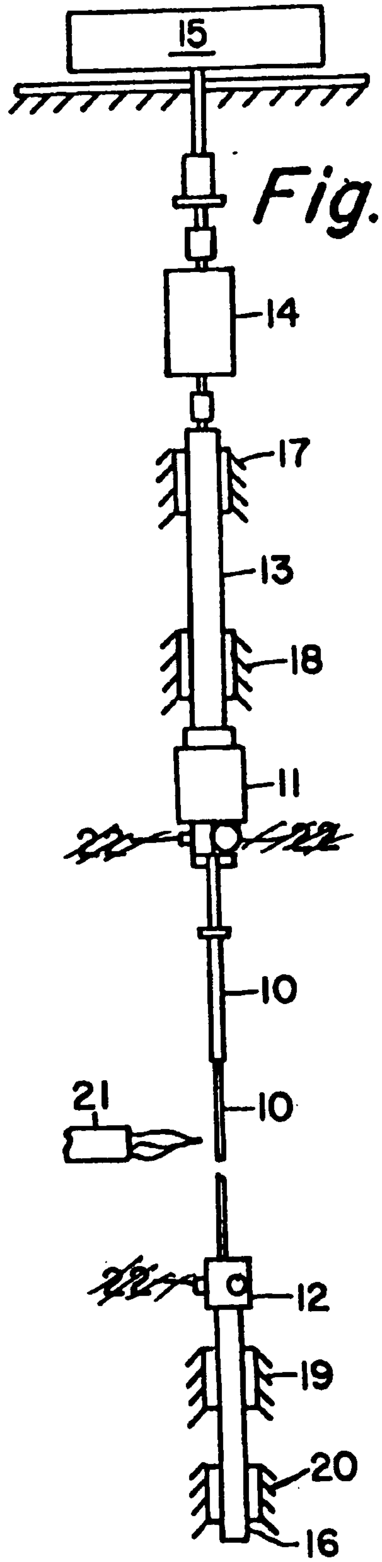

Fig. 2

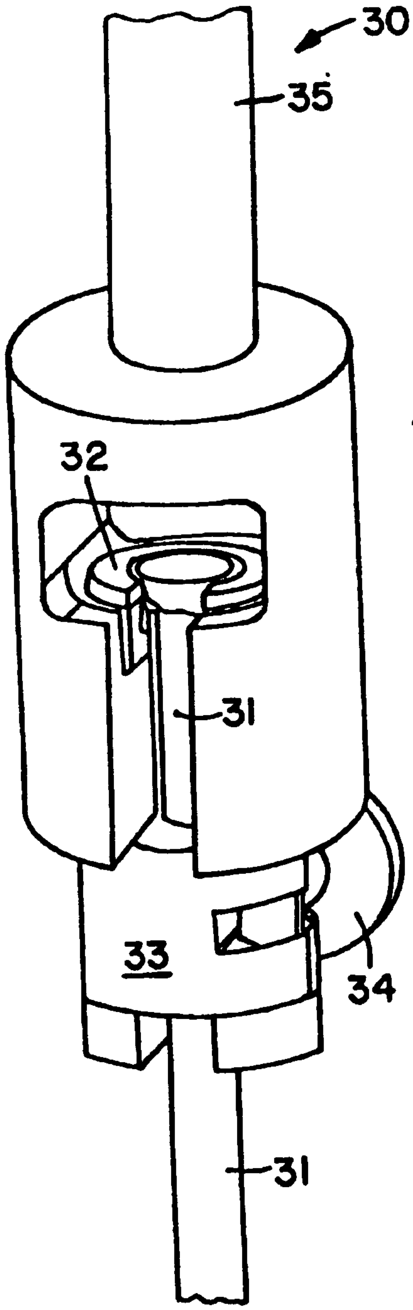

Fig. 3

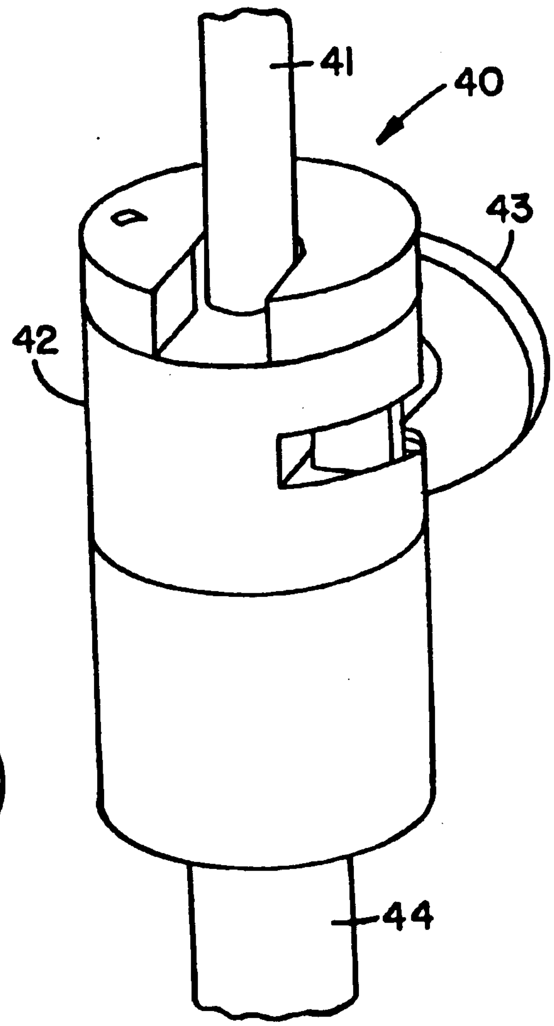

Fig. 4

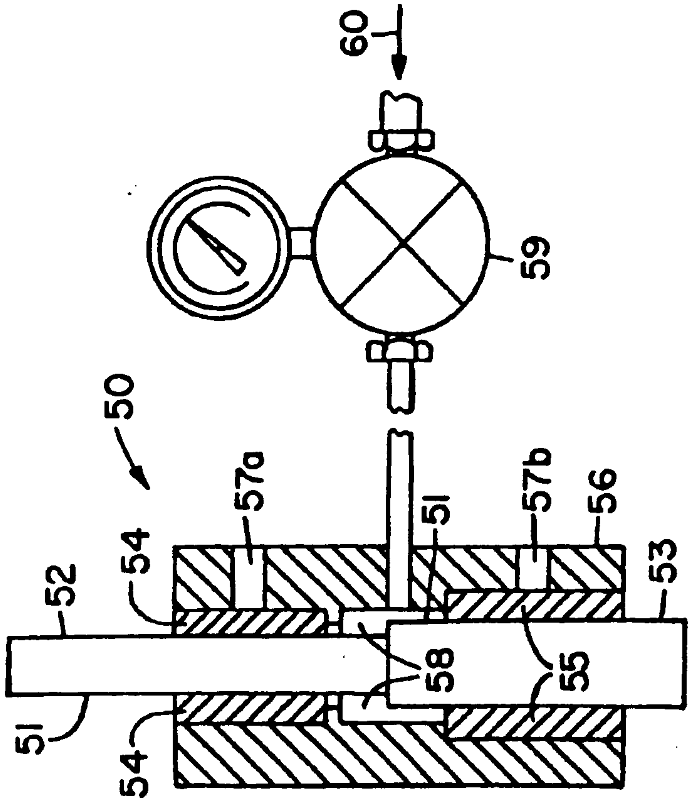

Fig. 5

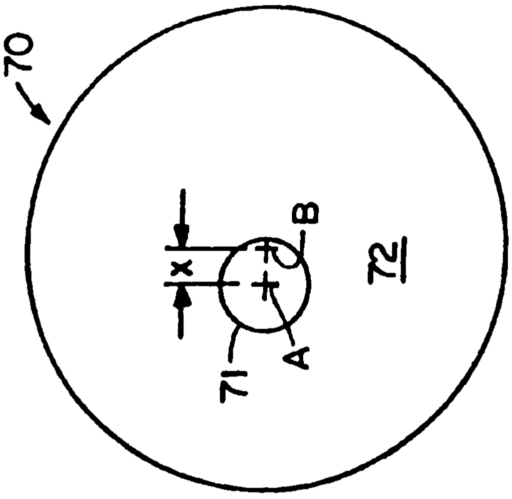

Fig. 7

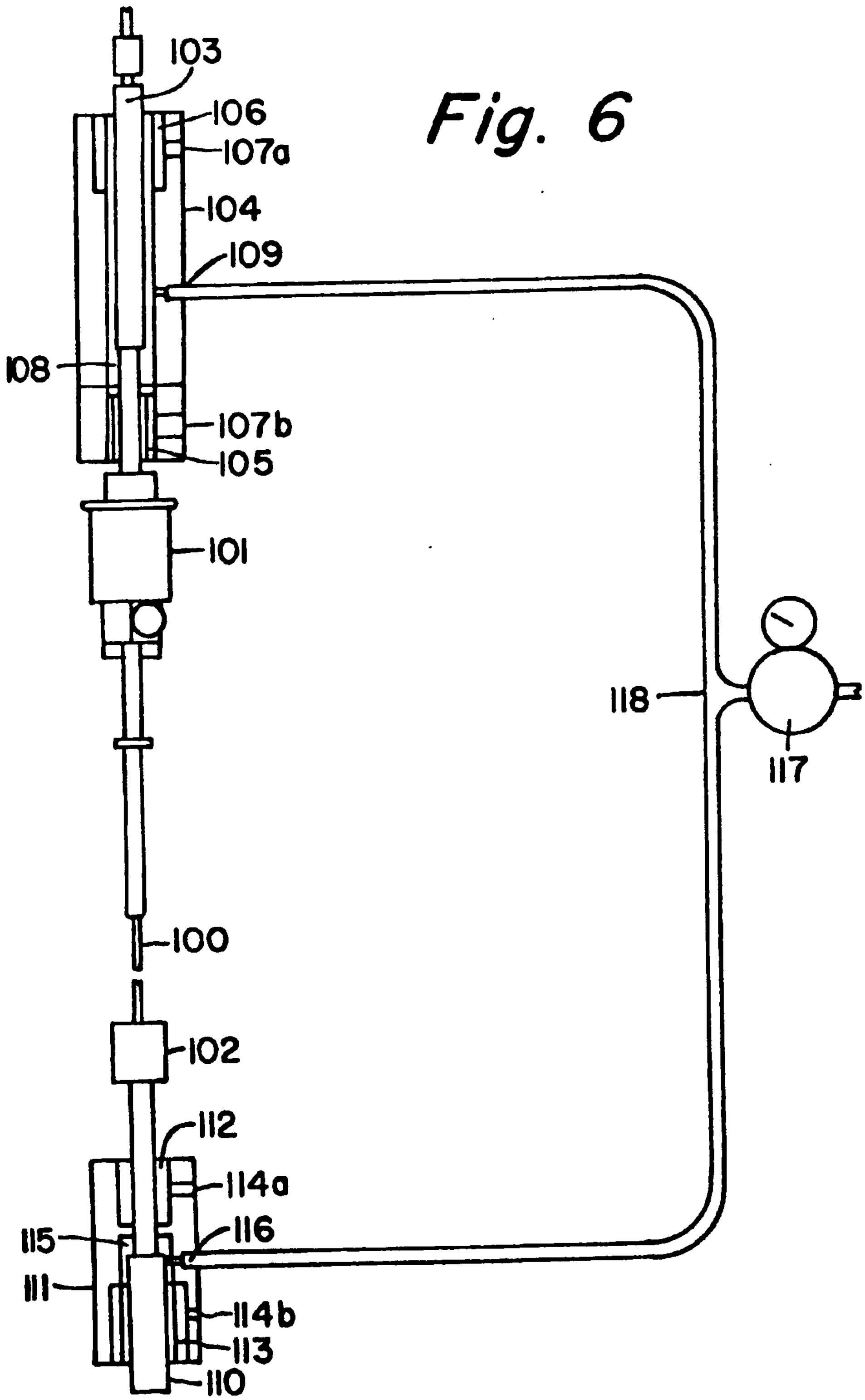
103
106
107a
104
109
108
107b
105
101
118
117
100
102
112
114a
116
115
111
114b
113
110

Fig. 6

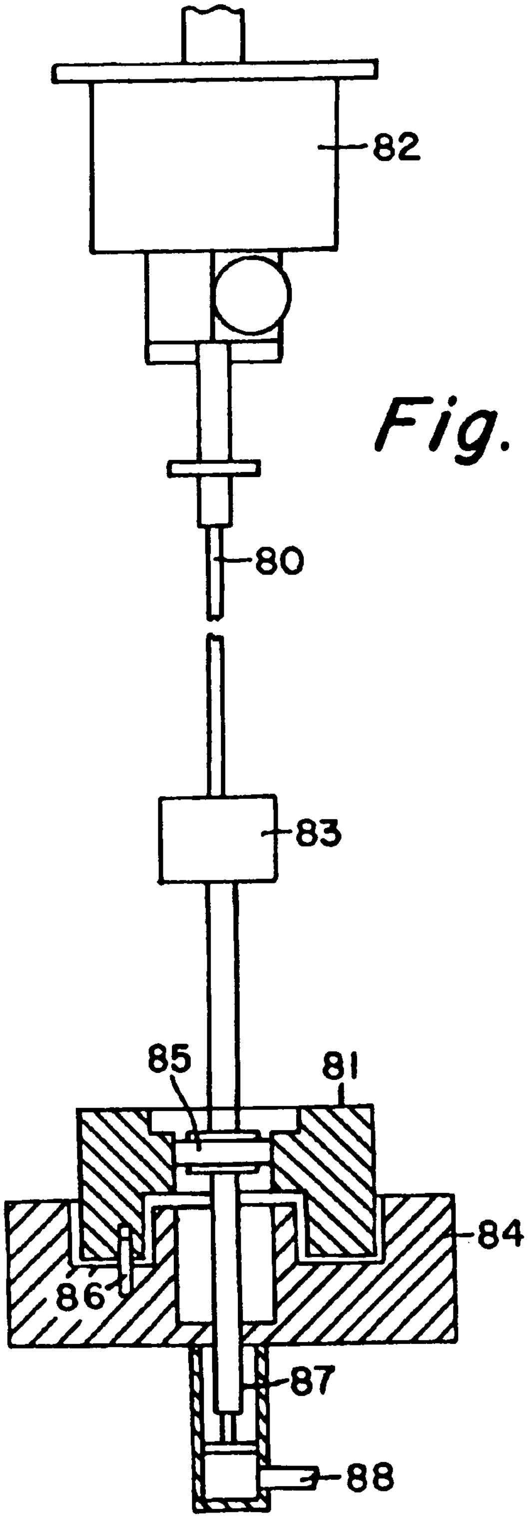

Fig. 8